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[Document Name] Scope of Claim

[Claim 1]

A manufacturing method of a master disc for an optical disc, comprising a step of forming an inorganic resist layer as a film onto a substrate,

the manufacturing method being characterized in that in the film forming step, the inorganic resist layer is formed as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer.

[Claim 2]

The manufacturing method of the master disc for the optical disc according to claim 1, characterized in that the film forming step is performed by a sputtering method.

[Claim 3]

The manufacturing method of the master disc for the optical disc according to claim 2, characterized in that in the film formation by the sputtering method, an alloy of a transition metal or an alloy oxidant of the transition metal is used as an inorganic resist material and oxygen or nitrogen is used as a reactive gas.

[Claim 4]

The manufacturing method of the master disc for the optical disc according to claim 3, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by changing at least one of a film forming electric power and a reactive gas ratio.

[Claim 5]

The manufacturing method of the master disc for the optical disc according to claim 4, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by keeping the film forming electric power constant and changing the reactive gas ratio.

[Claim 6]

The manufacturing method of the master disc for the optical disc according to claim 4, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by keeping the reactive gas ratio constant and changing and discharging the film forming electric power.

[Claim 7]

The manufacturing method of the master disc for the optical disc according to claim 5, characterized in that during the film formation by the sputtering method, the reactive gas ratio is sequentially changed, or the film formation by the sputtering method is temporarily stopped each time the reactive gas ratio is changed.

[Claim 8]

The manufacturing method of the master disc for the optical disc according to claim 6, characterized in that during the film formation by the sputtering method, the film forming electric power is sequentially changed and discharged, or the film formation by the sputtering method is temporarily

stopped each time the film forming electric power is changed.

[Claim 9]

The manufacturing method of the master disc for the optical disc according to claim 1, further comprising a step of selectively irradiating light to the substrate onto which the inorganic resist layer is formed as a film,

the manufacturing method being characterized in that in the irradiating step, at least two types of concave portions of different depths are arranged on the same surface by changing an exposing power in the irradiation.

[Claim 10]

The manufacturing method of the master disc for the optical disc according to claim 1, characterized in that in the film forming step, the inorganic resist layer is formed as a film so that an oxygen concentration of the inorganic resist layer becomes higher or lower at a portion closer to the substrate.

[Claim 11]

A film forming apparatus, comprising a film forming means for forming an inorganic resist layer as a film onto a substrate,

the film forming apparatus being characterized in that the film forming means forms the inorganic resist layer as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer.

[Claim 12]

The film forming apparatus according to claim 11, characterized in that the film forming means performs film

formation using a sputtering method.

[Claim 13]

The film forming apparatus according to claim 12, characterized in that in the film formation by the sputtering method, an alloy of a transition metal or an alloy oxidant of the transition metal is used as an inorganic resist material and oxygen or nitrogen is used as a reactive gas.

[Claim 14]

The film forming apparatus according to claim 13, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by changing at least one of a film forming electric power and a reactive gas ratio.

[Claim 15]

The film forming apparatus according to claim 14, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by keeping the film forming electric power constant and changing the reactive gas ratio.

[Claim 16]

The film forming apparatus according to claim 14, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by keeping the reactive gas ratio constant and changing and discharging the film forming electric power.

[Claim 17]

The film forming apparatus according to claim 15, characterized in that during the film formation by the sputtering method, the reactive gas ratio is sequentially changed or the film formation by the sputtering method is temporarily stopped each time the reactive gas ratio is changed.

[Claim 18]

The film forming apparatus according to claim 16, characterized in that during the film formation by the sputtering method, the film forming electric power is sequentially changed and discharged or the film formation by the sputtering method is temporarily stopped each time the film forming electric power is changed.

[Claim 19]

The film forming apparatus according to claim 11, characterized in that the film forming means forms the inorganic resist layer as a film so that an oxygen concentration of the inorganic resist layer becomes higher or lower at a portion closer to the substrate.

[Claim 20]

A master disc for an optical disc, characterized by: forming an inorganic resist layer as a film onto a substrate; and forming the inorganic resist layer as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer.

[Claim 21]

The master disc for an optical disc according to claim 20,

characterized in that the film formation is performed by a sputtering method.

[Claim 22]

The master disc for an optical disc according to claim 21, characterized in that in the film formation by the sputtering method, an alloy of a transition metal or an alloy oxidant of the transition metal is used as an inorganic resist material and, as necessary, oxygen or nitrogen is used as a reactive gas.

[Claim 23]

The master disc for an optical disc according to claim 22, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by changing at least one of a film forming electric power and a reactive gas ratio.

[Claim 24]

The master disc for an optical disc according to claim 23, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by keeping the film forming electric power constant and changing the reactive gas ratio.

[Claim 25]

The master disc for an optical disc according to claim 23, characterized in that in the film formation by the sputtering method, the inorganic resist layer of the different oxygen concentrations is formed as a film by keeping the reactive gas ratio constant and changing and discharging the film

forming electric power.

[Claim 26]

The master disc for an optical disc according to claim 24, characterized in that during the film formation by the sputtering method, the reactive gas ratio is sequentially changed or the film formation by the sputtering method is temporarily stopped each time the reactive gas ratio is changed.

[Claim 27]

The master disc for an optical disc according to claim 25, characterized in that during the film formation by the sputtering method, the film forming electric power is sequentially changed and discharged or the film formation by the sputtering method is temporarily stopped each time the film forming electric power is changed.

[Claim 28]

The master disc for an optical disc according to claim 20, characterized in that the inorganic resist layer is formed as a film so that an oxygen concentration of the inorganic resist layer becomes higher or lower at a portion closer to the substrate.

[Claim 29]

A master disc for an optical disc, characterized by: forming an inorganic resist layer as a film onto a substrate; forming the inorganic resist layer as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer; and arranging at least two types of concave

portions of different depths on the same surface as a result of irradiating different exposing power onto the substrate onto which the inorganic resist layer has been formed as a film.

[Claim 30]

The master disc for an optical disc according to claim 29, characterized in that the inorganic resist layer is formed as a film so that an oxygen concentration of the inorganic resist layer becomes lower at a portion closer to the substrate.

[Document Name] Specification

[Title of the Invention] MANUFACTURING METHOD OF MASTER DISC FOR OPTICAL DISC, FILM FORMING APPARATUS, AND MASTER DISC FOR OPTICAL DISC

[Technical Field]

[0001]

The present invention relates to a manufacturing method of a master disc for an optical disc that is manufactured by using an inorganic resist film, a film forming apparatus, and a master disc for an optical disc.

[Background Art]

[0002]

In recent years, along with the realization of a high capacity of an optical disc or the like, pattern precision below about several tens of nm has been necessary for a microfabrication of an optical device or the like. To realize such high precision, development is being progressed in various fields such as a light source, a resist material, a stepper, and the like.

[0003]

A method of shortening a wavelength of an exposing light source, a method of using an electron beam or ion beam which has finely been converged, and the like are effective as methods of improving microfabrication dimensional precision. However, since an apparatus having the exposing light source of a short wavelength or irradiating sources of the electron beam and the ion beam is extremely expensive,

such methods are improper for supplying a reasonable device.

[0004]

Therefore, a method of devising an irradiating method, a method of using a special mask called a phase shift mask, and the like have been proposed as methods of improving the microfabrication dimensional precision while using the same light source as that of the existing exposing apparatus. As further another method, a method of forming a resist by a multilayer, a method of using an inorganic resist, and the like have been tried.

[0005]

At present, for example, an exposing method in which an organic resist such as a novolak system resist, a chemical sensitizing resist, or the like and ultraviolet rays serving as an exposing light source are combined is generally used. Although the organic resist has generality and is widely used in the field of photolithography, since its molecular weight is large, a pattern of a boundary portion between an exposing portion and a non-exposing portion becomes obscure and there is a limitation in the microfabrication precision.

[0006]

On the other hand, in the inorganic resist, since its molecular weight is small, a clear pattern is obtained in the boundary portion between the exposing portion and the non-exposing portion and the fabrication of higher precision than that of the organic resist can be realized.

For example, there is an example of the microfabrication in which MoO_3, WO_3, or the like is used as a resist material and the ion beam is used as an exposing light source (refer to Non-patent document 1). There is also a fabrication example in which SiO_2 is used as a resist material and the electron beam is used as an exposing light source (refer to Non-patent document 2). Further, a method in which chalcogenide glass is used as a resist material and lasers having wavelengths of 476 nm and 532 nm and ultraviolet rays from a mercury xenon lamp are used as exposing light sources has also been examined (for example, refer to Non-patent document 3).

[0007]

[Non-patent document 1] Nobuyoshi Koshida, Kazuyoshi Yoshida, Shinichi Watanuki, Masanori Komuro, and Nobufumi Atoda: "50-nm Metal Line Fabrication by Focused Ion Beam and Oxide Resists", Jpn. J. Appl. Phys., Vol. 30 (1991), pp3246

[Non-patent document 2] Sucheta M. Gorwadkar, Toshimi Wada, Satoshi Hiraichi, Hiroshi Hiroshima, Kenichi Ishii, and Masanori Komuro: "SiO_2/c-Si Bilayer Electron-Beam Resist Process for Nano-Fabrication", Jpn. J. Appl. Phys., Vol. 35 (1996), pp6673

[Non-patent document 3] S.A. Kostyukevych: "Investigations and modeling of physical processes in an inorganic resist for use in UV and laser lithography", SPIE Vol. 3424 (1998), pp20

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0008]

However, in the case of using the electron beam or the ion beam as an exposing light source, although different kinds of inorganic resist materials can be combined as mentioned above and the concave and convex patterns can be also microfabricated by finely converging the electron beam or the ion beam, the apparatus having the irradiating sources of the electron beam and the ion beam is expensive as mentioned above and has a complicated structure, and accordingly it is improper for supplying the reasonable optical disc.

[0009]

In terms of such reasons, it is desirable that the light from a laser apparatus or the like built in the existing exposing apparatus, that is, ultraviolet rays or visible light can be used. However, as a material that can be cut by the ultraviolet rays or the like among the inorganic resist materials, only the chalcogenide material as mentioned above has been reported. This is because in the inorganic resist materials other than the chalcogenide material, the light such as ultraviolet rays is transmitted, an amount of absorption of a light energy is remarkably small, and it is not practical.

[0010]

Although a combination of the existing exposing

apparatus and the chalcogenide material mentioned above is a practical combination in view of economy, there is such a problem that the chalcogenide material contains a material such as Ag_2S_3, $Ag\text{-}As_2S_3$, $Ag_2Se\text{-}GeSe$, or the like which is harmful to the human body. Therefore, its specification is difficult from a viewpoint of industrial production.

[0011]

Therefore, there have been proposed methods of realizing the microfabrication of a master disc for an optical disc on the basis of a principle that in the case of an oxide whose oxygen content is slightly deviated from a stoichiometric composition of a transition metal oxide (incomplete oxide of transition metal) instead of a complete oxide of a transition metal such as MoO_3, WO_3, or the like, an absorption amount of the ultraviolet rays or the visible light is large and a chemical property is changed by the absorption.

[0012]

In addition, a method of using an incomplete oxide of, for example, W and Mo as a resist material, and causing a phase change by the heat of the exposing apparatus of the laser or the like, thereby eventually realizing the microfabrication at low costs is also incorporated in the above proposed methods.

[0013]

However, in the case where the inorganic resist is phase-changed by the heat of the laser or the like and

the fine concave/convex patterns such as pits, grooves, and the like are formed as mentioned above, the larger a distance from the surface of the inorganic resist is, the smaller the conductivity of the heat is, with the result that a change ratio of a phase change reaction (that is, change from amorphous to crystal) decreases. Therefore, there is a risk that, in a portion where the change ratio is small, a development shortage phenomenon occurs, the bottom surfaces of the pits, grooves, and the like are formed in the incomplete state, and further, angles of inclination or the like of the pits and grooves become gentle.

[0014]

In the method of using the phase change, since the shapes and the inclination angles of the fine concave/convex patterns such as pits, grooves, and the like are unconditionally determined in accordance with sensitivity of the inorganic resist master disc, an exposing power of the exposing apparatus, developing conditions, and the like, it is difficult to finely adjust them.

[0015]

Further, since a depth of fine concave/convex patterns such as pits, grooves, and the like (in other words, a height of stamper) is unconditionally determined by a thickness of inorganic resist film, it is difficult that the fine concave/convex patterns of different depths are formed in the same plane of the optical disc. For example, since the optimum depths are different with respect to the

fine concave/convex patterns of the pits for a ROM (Read Only Memory) and the grooves for the additional recording, a master disc for an optical disc having both of the pits and grooves (here, this type of an optical disc is referred to as a hybrid type optical disc) cannot be manufactured. Although the depths of the concave/convex patterns can be also controlled by adjusting the exposing power, according to such a method, it is difficult to stably form the concave/convex patterns of a predetermined depth.

[0016]

It is, therefore, an object of the present invention to provide a manufacturing method of a master disc for an optical disc, in which when an inorganic resist is phase-changed and fine concave/convex patterns such as pits, grooves, and the like are formed, sensitivity of an inorganic resist film is changed so that the bottom surfaces of the pits and grooves are stably formed in a flat shape and, further, angles of inclination of the pits and grooves are properly formed, and to provide a film forming apparatus, and the master disc for the optical disc manufactured by such a method.

[0017]

It is another object of the present invention to provide a manufacturing method of a master disc for an optical disc, in which shapes and angles of inclination of fine concave/convex portions such as pits, grooves, and the like are finely adjusted by changing sensitivity of an inorganic

resist film, and to provide a film forming apparatus and the master disc for the optical disc manufactured by such a method.

[0018]

It is further another object of the present invention to provide a manufacturing method of a master disc for an optical disc, in which sensitivity of an inorganic resist film is changed so that concave portions (fine concave/convex patterns such as pits, grooves, and the like) of different depths can be formed in the same plane, and to provide a film forming apparatus and the master disc for the optical disc manufactured by such a method.

[Means for Solving the Problems]

[0019]

The present invention is a manufacturing method of a master disc for an optical disc, including a step of forming an inorganic resist layer as a film onto a substrate, the manufacturing method being structured so that in the film forming step, the inorganic resist layer is formed as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer.

[0020] The present invention is a film forming apparatus including a film forming means for forming an inorganic resist layer as a film onto a substrate, the film forming apparatus being structured so that the film forming means forms the inorganic resist layer as a film at different oxygen concentrations in a thickness direction of the inorganic

resist layer.

[0021]

The present invention is a master disc for an optical disc, in which an inorganic resist layer is formed as a film onto a substrate and which is structured so that the inorganic resist layer is formed as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer.

[0022]

The present invention is a master disc for an optical disc, in which an inorganic resist layer is formed as a film onto a substrate, the inorganic resist layer is formed as a film at different oxygen concentrations in a thickness direction of the inorganic resist layer, and at least two types of concave portions of different depths are arranged on the same surface as a result of irradiating different exposing power onto the substrate onto which the inorganic resist layer has been formed as a film.

[Effect of the Invention]

[0023]

According to the present invention, there is provided the manufacturing method of the master disc for the optical disc whereby in the case of forming the fine concave/convex patterns such as pits, grooves, and the like by phase-changing the inorganic resist, the sensitivity of the inorganic resist film is changed so that the bottom surfaces of the pits and grooves are stably formed in a flat

shape and to provide the film forming apparatus and the master disc for the optical disc manufactured by such a method.

[0024]

Further, according to the present invention, there is provided the manufacturing method of the master disc for the optical disc whereby the shapes and the inclination angles of the fine concave/convex portions such as pits, grooves, and the like are finely adjusted by changing the sensitivity of the inorganic resist film or the sensitivity of the inorganic resist film is changed so that the concave portions of the different depths can be formed in the same plane and to provide the film forming apparatus and the master disc for the optical disc manufactured by such a method.

[Best Mode for Carrying Out the Invention]

[0025]

Sensitivity of an inorganic resist changes in accordance with a composition ratio (oxygen content) of an alloy in an inorganic resist layer and the composition ratio changes in accordance with a film forming electric power or a reactive gas ratio during the film forming process of the inorganic resist layer. Therefore, in the present invention, by using such a principle, it is intended to solve the foregoing problems by sequentially changing the sensitivity of the inorganic resist in one resist layer. Furthermore, herein, the sensitivity represents a degree of a phase change in the inorganic resist when the inorganic

resist is heated. In the present invention, since it is assumed that adoption of an expensive and complicated apparatus of electron beam or the like is avoided and an exposing apparatus of laser or the like is used, the above-mentioned sensitivity can be considered as an exposure sensitivity.

[0026]

Next, a manufacturing method of a master disc for an optical disc according to a first embodiment of the present invention will be described with reference to Fig. 1. First, as shown in Fig. 1A, a resist layer 2 made of a predetermined inorganic resist material is formed as a film onto a substrate 1 made of glass or an Si wafer. As a film forming method in this instance, for example, a sputtering method can be mentioned. In the present invention, for example, a film forming apparatus that can embody the film forming process by the sputtering method is used.

[0027]

Although a film thickness of the inorganic resist layer 2 can be arbitrarily set, it is necessary to set the thickness so as to obtain a desired depth (height) of a pit or a groove. In the case of a Blu-ray Disc (BLU-RAY Disc (registered trademark)), it is desirable to set the thickness in a range of 10 nm to 80 nm. In the case of a DVD (Digital Versatile Disc), it is desirable to set the thickness in a range of 100 nm to 190 nm. As an inorganic resist material, for example, an alloy of a transition metal is used. As

a reactive gas, for example, oxygen or nitrogen is used.

[0028]

In the embodiment, the film forming process is executed in such a manner that the more the position is away from the surface of the inorganic resist film (the inorganic resist layer 2), that is, the more the position is close to the surface of the substrate 1, the more the sensitivity of the inorganic resist layer 2 increases. As a method of gradually increasing the sensitivity of the inorganic resist film in this way, for example, there are the following two methods using the reactive sputtering.

[0029]

[Method 1]

(1) In a sputtering apparatus, a film forming electric power is set to a predetermined value (for example, 150W) and a discharge is performed.

(2) During the film forming process of the inorganic resist film, the reactive gas ratio is changed as follows at the initial, middle, and end stages of the film forming process.

(a) Initial stage of the film forming process

1st layer, 2 minutes, 20nm thickness: reactive gas ratio = 9%

(b) Middle stage of the film forming process

2nd layer, 3 minutes, 30nm thickness: reactive gas ratio = 8%

(c) End stage of the film forming process

3rd layer, 2 minutes, 20nm thickness: reactive gas ratio = 7%

Here, for example, in the stage (a), the sputtering is executed for 2 minutes and the resist film having the thickness of 20 nm is formed. Furthermore, the reactive gas ratio is a ratio of the reactive gas to the sum of the discharge gas and the reactive gas and is expressed by $O_2/(Ar + O_2)$, for example.

[0030]

[Method 2]

(1) In the sputtering apparatus, the reactive gas ratio is set to a predetermined value (for example, 8%) and the discharge is performed.

Or, the discharge can be also performed by using the target of an alloy oxidant of the same oxygen content without injecting the reactive gas.

(2) During the film forming process of the inorganic resist film, the film forming electric power is changed.

(a) Initial stage of the film forming process

1st layer, 2 minutes, 20nm thickness: film forming electric power = 100W

(b) Middle stage of the film forming process

2nd layer, 3 minutes, 30nm thickness: film forming electric power = 150W

(c) End stage of the film forming process

3rd layer, 2 minutes, 20nm thickness: film forming electric power = 200W

[0031]

Although the film forming process is executed under the three film forming conditions in the examples of the methods 1 and 2 mentioned above, those conditions can be sequentially switched during the continuous film forming process or when the film forming conditions are switched, it is also possible to temporarily stop the film forming process and execute the intermittent film forming process.

[0032]

According to such control of the sputtering, at the initial stage of the film forming process, an oxygen concentration of the film is large and the sensitivity is high. On the other hand, at the end stage of the film forming process, the oxygen concentration is small and the sensitivity is low. Therefore, the inorganic resist layer in which the sensitivity is higher at a position far from the surface of the inorganic resist film (that is, position close to the substrate 1) is formed.

[0033]

The individual conditions and the number of condition changing times in each of the methods 1 and 2 can be arbitrarily selected so as to obtain the desired shapes and inclination angles of the fine concave/convex patterns such as pits and grooves and are not limited to those shown in the embodiment. Furthermore, although the film forming process has been executed by fixing one of the film forming electric power and the reactive gas ratio and changing the

other one in the methods 1 and 2, it is also possible to change both of the film forming electric power and the reactive gas ratio and preferably change the oxygen concentration of the resist film.

[0034]

Since the inorganic resist film in which the sensitivity is high in a portion near the bottom surfaces of the fine concave/convex patterns such as pits and grooves is provided by the control of the sputtering, the flat bottom surfaces in which even if the laser or the like is irradiated, the development shortage phenomenon is difficult to occur near the bottom surfaces are obtained.

[0035]

Subsequently, as shown in Fig. 1B, a selective irradiation is performed on the resist layer 2 by using an exposing apparatus 3 for irradiating a laser or the like. With respect to pits for a ROM, such an irradiation is a selective irradiation corresponding to signal patterns to be recorded. With respect to grooves for the additional recording, it is a selective irradiation to form the grooves. For example, a blue laser diode which generates a laser beam of a wavelength of 405 nm is used for a laser in this case.

[0036]

After that, the substrate on which the film is formed is developed using an alkali liquid by using a developing apparatus. A dipping method by dipping, a method of coating chemicals onto the substrate which is rotated

by a spinner, or the like is used as a developing method. As a developer, an organic alkali developer such as NMD-3 or the like, an inorganic alkali developer such as KOH, NaOH, phosphoric acid system or the like is used. After the development, a master disc 4 for an optical disc as shown in Fig. 1C is obtained.

[0037]

Subsequently, as shown in Fig. 1D, a metal nickel film 5 is precipitated onto the concave/convex pattern surface of the master disc 4 for the optical disc by an electroforming method. After the film 5 is peeled off from the master disc 4 for the optical disc, a predetermined process is performed and a stamper 6 for molding onto which the concave/convex patterns of the master disc 4 for the optical disc have been transferred is obtained as shown in Fig. 1E.

[0038]

Next, a manufacturing method of a master disc for an optical disc according to a second embodiment of the present invention will be described. According to this second embodiment, the film forming step and the laser irradiating (exposing) step in the first embodiment mentioned above are changed. Only the portions different from the processing steps in the first embodiment will be described here. On the contrary to the first embodiment, the film forming process is executed in such a manner that as the position becomes far away from the surface of the

inorganic resist film (the inorganic resist layer 2), the sensitivity of the inorganic resist film is decreased. As a method of gradually decreasing the sensitivity of the inorganic resist film as described above, for example, there are the following two methods. In addition, for example, an alloy oxidant of a transition metal is used as an inorganic resist material, and oxygen or nitrogen is used as a reactive gas.

[Method 3]

(1) In the sputtering apparatus, the film forming electric power is set to a predetermined value (for example, 150W) and the discharge is performed.

(2) During the film forming process of the inorganic resist film, the reactive gas ratio is changed as follows at the initial, middle, and end stages of the film forming process. The oxygen content is adjusted by changing the reactive gas ratio in a manner similar to the foregoing method 1.

(a) Initial stage of the film forming process

1st layer, 2 minutes, 20nm thickness: reactive gas ratio = 7%

(b) Middle stage of the film forming process

2nd layer, 3 minutes, 30nm thickness: reactive gas ratio = 8%

(c) End stage of the film forming process

3rd layer, 2 minutes, 20nm thickness: reactive gas ratio = 9%

Here, for example, in the stage (a), the sputtering is executed for 2 minutes and the resist film having the thickness of 20 nm is formed. Furthermore, the reactive gas ratio is expressed by $O_2/(Ar + O_2)$.

[0039]

[Method 4]

(1) In the sputtering apparatus, the reactive gas ratio is set to be a predetermined value (for example, 8%) and the discharge is performed.

Or, the discharge can be also performed by using the target of an alloy oxidant of the same oxygen content without injecting the reactive gas.

(2) During the film forming process of the inorganic resist film, the film forming electric power is changed.

(a) Initial stage of the film forming process

1st layer, 2 minutes, 20nm thickness: film forming electric power = 200W

(b) Middle stage of the film forming process

2nd layer, 3 minutes, 30nm thickness: film forming electric power = 150W

(c) End stage of the film forming process

3rd layer, 2 minutes, 20nm thickness: film forming electric power = 100W

[0040]

Although the film forming process is executed under the three film forming conditions in the examples of the methods 3 and 4 mentioned above, those conditions can

be sequentially switched during the continuous film forming process or when the film forming conditions are switched, it is also possible to temporarily stop the film forming process and execute the intermittent film forming process.

[0041]

By such control of the sputtering, at the initial stage of the film forming process, an oxygen concentration of the film is small and the sensitivity is low. On the other hand, at the end stage of the film forming process, the oxygen concentration is large and the sensitivity is high. Therefore, the inorganic resist layer in which the sensitivity is higher at a position far from the surface of the inorganic resist film (that is, position close to the substrate 1) is formed.

[0042]

The individual conditions and the number of condition changing times in each of the methods 3 and 4 can be arbitrarily selected so as to obtain the desired shapes and inclination angles of the fine concave/convex patterns such as pits and grooves and are not limited to this embodiment. Moreover, although the film forming process has been executed by fixing one of the film forming electric power and the reactive gas ratio and changing the other one in the methods 3 and 4, it is also possible to change both of the film forming electric power and the reactive gas ratio and suitably change the oxygen concentration of the resist film.

[0043]

After that, as shown in Fig. 1B, a selective irradiation is performed on the resist layer 2 by using an exposing apparatus 3 for irradiating a laser or the like. With respect to pits for a ROM, such an irradiation is a selective irradiation corresponding to signal patterns to be recorded. With respect to grooves for the additional recording, it is a continuous irradiation to form the grooves. For example, a blue laser diode which generates a laser beam of a wavelength of 405 nm is used for a laser in this case.

[0044]

Here, with respect to the pit for the ROM, the laser beam is irradiated by using the exposing power of about 10 mW. With respect the groove for the additional recording, the laser beam is irradiated by using the exposing power of about 15 mW. Thus, a hybrid optical disc having concave portions of different depths, that is, having pit patterns for the ROM and groove patterns for the additional recording in the same disc can be manufactured.

[0045]

In the second embodiment (hybrid optical disc having the ROM of a DVD and the grooves for the additional recording), when the developing process is completed after the film forming process and the exposing process that are described above, two concave portions each having a different depth is formed on the master disc 4 for the optical disc as shown in Fig. 2. The ROM pit 14 has a depth that reaches the inorganic resist film formed at the middle stage of the

film forming process (at the depth of about 125 nm from the surface of the inorganic resist film, obtained by cutting of a second layer 12 and a third layer 13). The groove for the additional recording has a depth that reaches the inorganic resist film formed at the initial stage of the film forming process (at the depth of about 180 nm from the surface of the inorganic resist film, obtained by cutting of a first layer 11 to the third layer 13).

[0046]

Although two kinds of the concave portions of the different depths have been formed to manufacture the hybrid optical disc in the this embodiment, the concave portions of various depths can be arranged on the same surface of the optical disc by the film forming process by the sputtering and the control of the exposing power in the exposing step as mentioned above.

[0047]

Next, a film forming apparatus (sputtering apparatus) 20 which can embody the film forming method of the present invention will be described with reference to Fig. 3. In the film forming apparatus 20, a cathode 22 and an anode 23 are provided in a vacuum film forming chamber 21, a target material 24 (in this case, an alloy of a transition metal, or an alloy oxide of a transition metal) is attached to the cathode 22, and a substrate 25 is attached to the anode 23.

[0048]

A discharge gas (for example, Ar gas) is enclosed in a cylinder 26 and supplied into the film forming chamber 21 through a stop valve 28 under the control of a mass flow controller 27. The mass flow controller 27 performs control so as to feed a predetermined quantity of discharge gas into the film forming chamber 21 at a predetermined timing during the film forming process.

[0049]

In the case of executing the reactive sputtering, a reactive gas (for example, oxygen or nitrogen) is supplied from a cylinder 29 into the film forming chamber 21 through a mass flow controller 30 and a stop valve 31. The mass flow controller 30 performs control so as to feed a predetermined quantity of reactive gas into the film forming chamber 21 at a predetermined timing during the film forming process.

[0050]

At a point of time when the discharge gas and the reactive gas have been introduced into the film forming chamber 21, by applying a predetermined voltage (film forming electric power) between the cathode 22 and the anode 23, a glow discharge is executed. A plasma generated by the glow discharge is used as an energy source and a film forming substance sputtered from the target material 24 is deposited onto the substrate 25, thereby forming a thin film. Such control of the film forming electric power is made by a film forming electric power control 33.

[0051]

Furthermore, the film forming apparatus 20 is classified into a DC (Direct Current) type power source and an RF (Radio Frequency) type power source in dependence on whether a DC power source is used or an RF power source is used as a power source.

[0052]

The film forming apparatus 20 makes the change control of the reactive gas ratio as mentioned above by a reactive gas ratio control 32 including the mass flow controllers 27 and 30 and makes the change control of the film forming electric power by the film forming electric power control 33. The reactive gas ratio control 32 and the film forming electric power control 33 are controlled by, for example, a microcomputer and control contents are instructed through programs or the like loaded in a memory.

[Brief Description of Drawings]

[0053]

[Fig. 1] A schematic diagram showing each step of a manufacturing method of a master disc for an optical disc according to the present invention.

[Fig. 2] A schematic diagram showing a mode of a case where fine concave/convex patterns each having a different depth are formed in the same surface of the optical disc by the manufacturing method of the master disc for the optical disc according to the present invention.

[Fig. 3] A block diagram showing a structure of

a film forming apparatus which can embody the manufacturing method of the master disc for the optical disc according to the present invention.

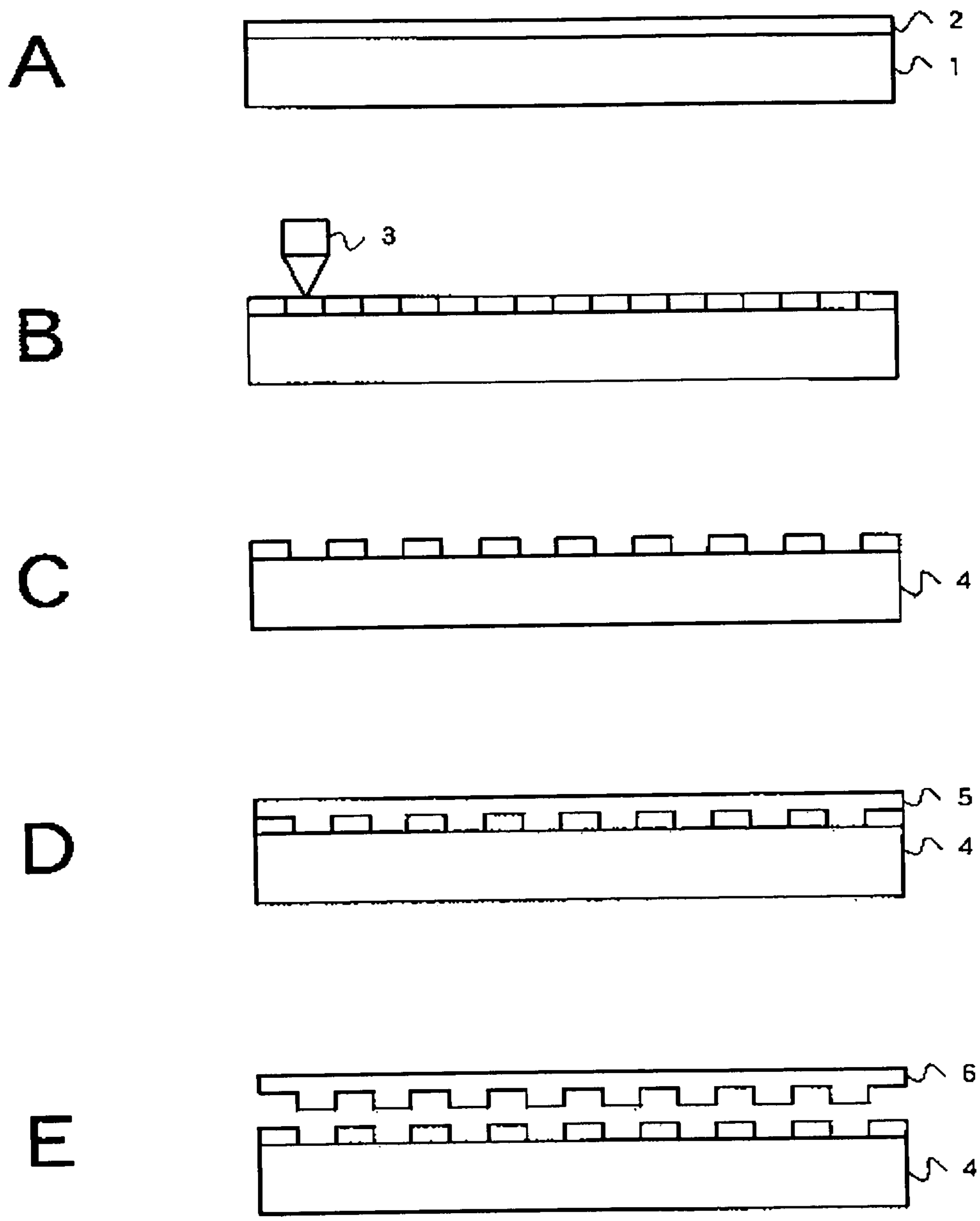
[Brief Description of Reference Numerals]

[0054]

1	substrate
2	resist layer
3	exposing apparatus
4	master disc for optical disc
5	metal nickel film
6	stamper for molding
20	film forming apparatus

【書類名】図面

【図１】



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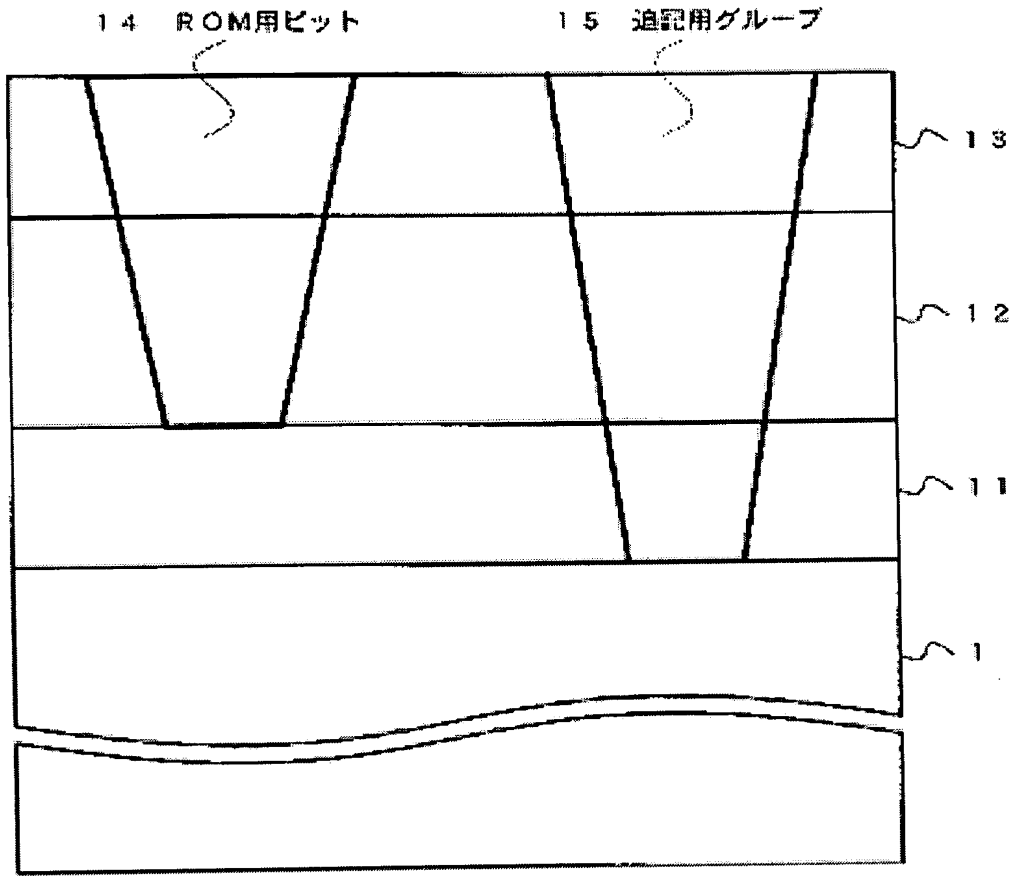
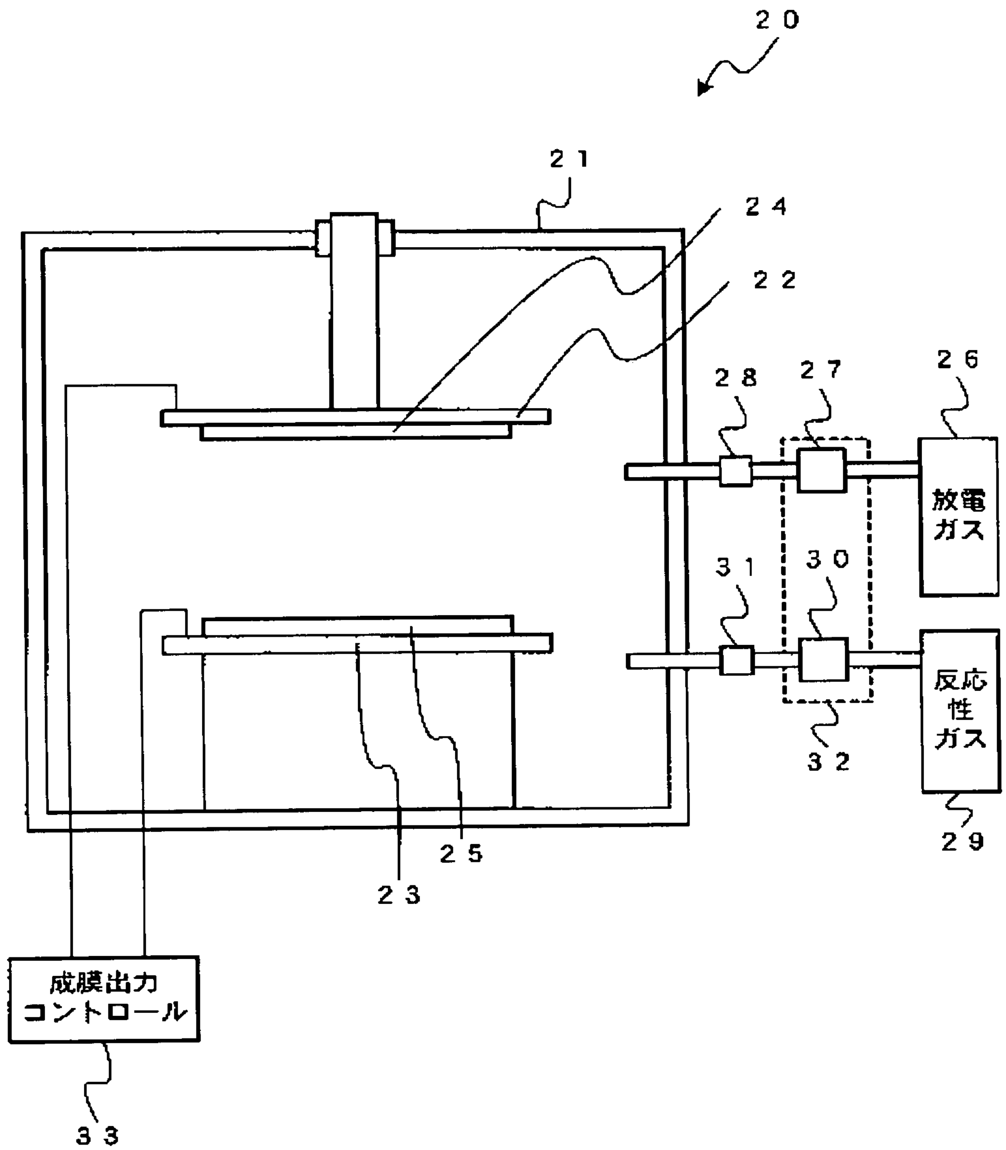


【図３】



【書類名】図面　[Document Name] Drawings

【図１】　[FIG. 1]

【図２】　[FIG. 2]

１４　ROM PIT

１５　GROOVE FOR ADDITIONAL RECORDING

【図３】　[FIG. 3]

２６　DISCHARGE GAS

２９　REACTIVE GAS

３３　FILM FORMING ELECTRIC POWER CONTROL

[Document Name] Abstract of the Disclosure

[Abstract]

[Object] To provide a manufacturing method of a master disc for an optical disc, by which in a case of forming fine concave/convex patterns such as pits, grooves, and the like by phase-changing an inorganic resist, sensitivity of an inorganic resist film is changed so that bottom surfaces of the pits and grooves are stably formed in a flat shape, and to provide a film forming apparatus and a master disc for an optical disc manufactured by such a method

[Solution] The film forming apparatus forms a resist layer 2 made of a predetermined inorganic resist material as a film onto a substrate 1 made of glass or the like by, for example, a sputtering method. For example, an alloy of a transition metal is used as the inorganic resist material, and oxygen, nitrogen, or the like is used as a reactive gas. By such control of the sputtering, at the initial stage of the film forming process, an oxygen concentration of the film is large and the sensitivity is high. On the other hand, at the end stage of the film forming process, the oxygen concentration is small and the sensitivity is low. Therefore, the inorganic resist layer in which the sensitivity is higher at a position far from a surface of the inorganic resist layer 2 (in other words, position close to the substrate 1) is formed.

[Selected Drawing] Fig. 1